German industry confirms standards for prevention and protection of machine tool fires

The German machine tool industry, in association with engineering companies, universities and suppliers, has, after months of research, released a new industry standard information document entitled "Machine Tool Fire and Explosion – Prevention and Protection."

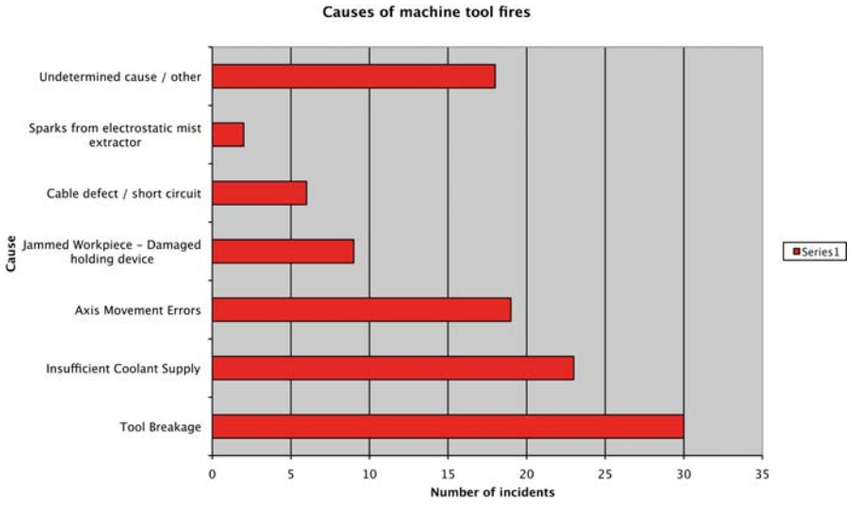
Participants in the programme were numerous but included Index, Traub, Deckel Maho, Daimler, Fuchs (lubricants) and Kraft & Bauer (fire extinguishing systems) and the VDW (Association of German machine tool manufacturers) plus various government bodies, with the aim of understanding the main causes of machine tool fires, what happens during a fire incident and to formulate best practice for dealing with them.

The report notes that low-viscosity, flammable metalworking fluids ("MWF"), neat oils rather than soluble ones, are increasingly being used to achieve more efficient and economic machining on grinding, milling, turning and EDM machines. The annual usage in Germany alone of neat oils on machine tools is now in excess of 40,000 tons per year. This trend brings the topic of fire and explosion protection and prevention for machine tools to the fore. Depending on the type of machining, reactions of the oil/air mixture may occur in the interior of the machine tool, which if violent and followed by a fire can be the cause of accidents with severe material and fire damage. Besides injuries to persons, the consequences to engineering companies may be high due to losses because of production stoppages right through to insolvency. Many engineering companies think that insurance is sufficient, but don't take into account that it may take many months before factories and machines may be replaced. Their customers might well not be prepared to wait and would instead go and find alternative suppliers whilst they were still trying to recover from a fire incident.

Starting from a legal basis, the aim is to protect workers as comprehensively and efficiently as possible against fire and explosion hazards during the use of machine tools. Both manufacturers of machinery and also users of machine tools have key obligations. When using flammable metalworking fluids, the employer has the duty to determine within the framework of a risk assessment if a hazard caused by fire or explosions on machines is possible. For this purpose, when purchasing any machine tool, he should firstly ensure that the machine is compatible with the metalworking fluids intended to be used. It is now generally respected that if any machine uses oil, and/or has a capacity to generate a spark, or is machining a potentially combustible material such as titanium or magnesium alloys, then it represents a major fire risk. The machine manufacturer takes this information into account when analyzing the risk for the identification and specification of the protection concept for the machine; usually by means of fitting an automatic fire extinguishing system and explosion flap devices. The end user has responsibilities to ensure that the fire protection systems are serviced, usually at least annually, by a responsible validated service technician; usually the fire extinguisher makers own engineers.

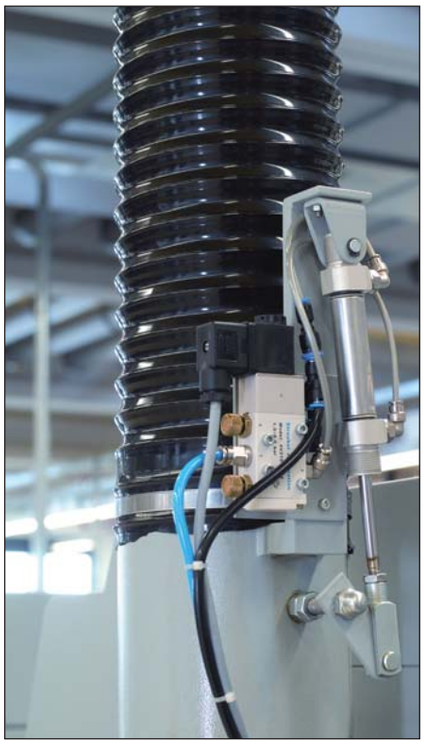
So what are the causes of machine tool fires? Within the framework of a study carried out by the VDW, about 150 machine tool fires were investigated and the causes for these fires are shown in the following chart:

Most incidents were connected with the generation of incandescent chips, high-energy sparks or hot surfaces, which act as ignition sources. Root causes included broken or worn milling cutters, drills, turning inserts and grinding wheels. As a consequence of technical developments concerning machine tool feeds and speeds together with the trend towards low-viscosity metalworking fluids used at very high pressures, then the fire risk has



increased dramatically in recent years. In the immediate vicinity of the machining zone a reactive mixture of metalworking fluids (MWF) and air is formed, which may be ignited by the above mentioned ignition sources. The resulting fire propagates very quickly through the whole interior of the machine tool. The pressure increase accompanying ignition is less important than in the case of an explosion inside a totally enclosed machine. However, due to the pressure increase inside the machine, flame ejections may occur through gaps, pressed-open enclosure doors, feeding and chip removal openings and pressure relief openings, if no relevant provisions are taken.

In case the machine's encapsulation is insufficiently pressure-resistant, a potential injury hazard exists to persons if housing parts blow-off or flames eject when the MWF



Mist Extraction Safety Flap Device (courtesy of Kraft & Bauer)

mixture is ignited. In such cases, a pressure relief device should be fitted for such pressure peaks with flames and hot combustion gases resulting from the ignition being directed to safe areas (usually upwards and away from where operators may be present).

As machine enclosures often only have low pressure resistances (<< 100 mbar), the response pressure of relief devices fitted to machine tools should be less than 5 mbar. The pressure flap safety devices only opens briefly and shuts back closed. This should prevent the rekindling of flames by the introduction of air as well as avoiding flame propagation. A typical safety flap designed to shut off access for flames and explosions through mist extraction ducts is shown here:

For the protection of machine tools, automatic fire extinguishing systems with gaseous extinguishing agents, commonly either carbon dioxide or in case of machining titanium or magnesium Argon Gas, from leading manufacturers such as Kraft & Bauer who have pioneered designs specifically for use on machine tools, are generally used. The aim is the extinguishing of any burning metalworking fluids (oil fires). The generally accepted requirements for use of these devices are that if a machine is ran automatically then a fully automatic fire system must be used and if a machine can only ever be ran manually then the fitment of a manually activated system is otherwise acceptable. However, in both cases the system must be fully integrated within the machine tool itself and having hand-held or externally used systems is not acceptable.

Typical manually activated fire system

Control system for automatic fire system in conjunction with mist extraction protection

An automatic extinguishing system for machine tools consists of, amongst others, the following major components:

- Fire detection elements (in the machining room of the machine tool and at other places, where fire hazards exist, e.g. extraction system, chip conveyors)
- Fire alarm centre and/or control device (fire detection, alarming, monitoring and control of the extinguishing system, if applicable, control of equipment like machine shut-down, shut-off or closing of the extraction system
- Manual activation (at the control panel or in the vicinity of the machine),
- Extinguishing agent tank (including a loss monitoring device such as an automatic bottle weighing system) and distributor pipe circuit into the interior of the machine
- Extinguishing nozzles (appropriate arrangement inside the machine, in order to uniformly distribute the extinguishing agent over the entire extinguishing area)
- Alarming devices, optical and/or acoustic (acoustic alarms must be at least 5 dB louder than the background noise),
- And additionally if applicable, interlocking option for the extinguishing system, time switch (electrical, non-electrical) and

Typical optical sensor with nozzle for fire suppressant gas being released

pressure relief device. It also has to be ensured that a fire is detected as early as possible (e.g. by means of automatic fire detection) and that the fire extinguishing system is activated without delay and the fire detection elements are a key criterion for fire protection. They must guarantee the safe detection of fires in a fast and reliable way and activate the extinguishing process via the control system. For automatic activation of the extinguishing system thermal heat detection elements are used in conjunction with optical fire detection elements (Infra Red or Ultra Violet light systems).

Optical sensors must be kept clean and this is done, for example, by constant air purging. The functions “cable breakage” and “window malfunction” should also be monitored (the optical detector controls itself for vision) and fire detection equipment must correspond to the state-of-the-art (e.g. DIN EN 12 094-9). For planning and installation, the manufacturer’s specifications and the rules of technology should be taken into account besides risk-specific aspects. Special solutions must be specified for each application and their efficiency and reliability must be verified by fire tests and tests of the relevant components and systems by a specialist installer.

Optional items such as devices that constantly monitor a bottles weight (in the case of $C0_2$) or a bottles pressure (in the case of Argon) should be considered as these prevent machine tools from being used with empty bottles.

Mandatory annual maintenance tests have the purpose of the timely detection and repair of damage as well as ensuring safe operation and these are also required by insurance companies. Machine tools must be tested for fire safety prior to initial commissioning when new, recurrently thereafter in accordance with the suppliers

An example of a bottle weighing system

maintenance specifications (at least annually) and after any maintenance work which may affect safety. For the testing of working equipment the qualification of the person to be appointed to carry out the test must be validated, with certification from the fire system manufacture available, and the service company must record the test results. The person carrying out the routine checks must be a “competent person”. The records shall be kept for an appropriate period of time with both the end user and the service provider holding copies.

The checks on the correct functioning of the extinguishing system should be carried out at least once a year or as needed (e.g. after fire damage). In practice, the test is generally carried out within the framework of servicing and maintenance work by the installing company. Furthermore a test by independent third parties/experts (also replaces tests by competent persons) is required at least every 2 years. Tests by competent persons and by experts are possible every alternate year. The results of the tests must be recorded in a test book or a test report. The records of the tests should ideally be stored over the whole operational lifetime of the extinguishing system but for at least 4 years.

For machine tools, the Directive 98/37/EC, also called the “Machinery Directive” should be used and annex I, clauses1.5.6 and 1.5.7 of the Directive 98/37/EC state that machines shall be designed and constructed in a way to exclude any risk of fire and avoid any explosion hazard. The standards DIN EN 13 478 “Safety of machinery – Fire prevention and protection” and DIN EN 1127-1 “Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology” may also provide assistance.

References: A complete list of references is available from the original documentation published by Deutsche Gesetzliche Unfallversicherung (DGUV), the umbrella association of the accident insurance institutions for the industrial and public sectors in Germany).

Additional information on fire detection and extinguishing systems for machine tools is available from:

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